Inter- and intraannual glacier elevation changes derived from TanDEM-X DEM data on the example of Inylchek Glacier, Tien Shan

Julia Neelmeijer[1,2], Mahdi Motagh[1,3] and Bodo Bookhagen[2]

1) GFZ German Research Centre for Geosciences, Section 1.4 Remote Sensing, Telegrafenberg, 14473 Potsdam, Germany
2) Institute of Earth and Environmental Science, University of Potsdam, 14476 Potsdam, Germany
3) Institute of Photogrammetry and GeoInformation, Leibniz University Hannover, 30167 Hannover, Germany

neelmeijer@gfz-potsdam.de

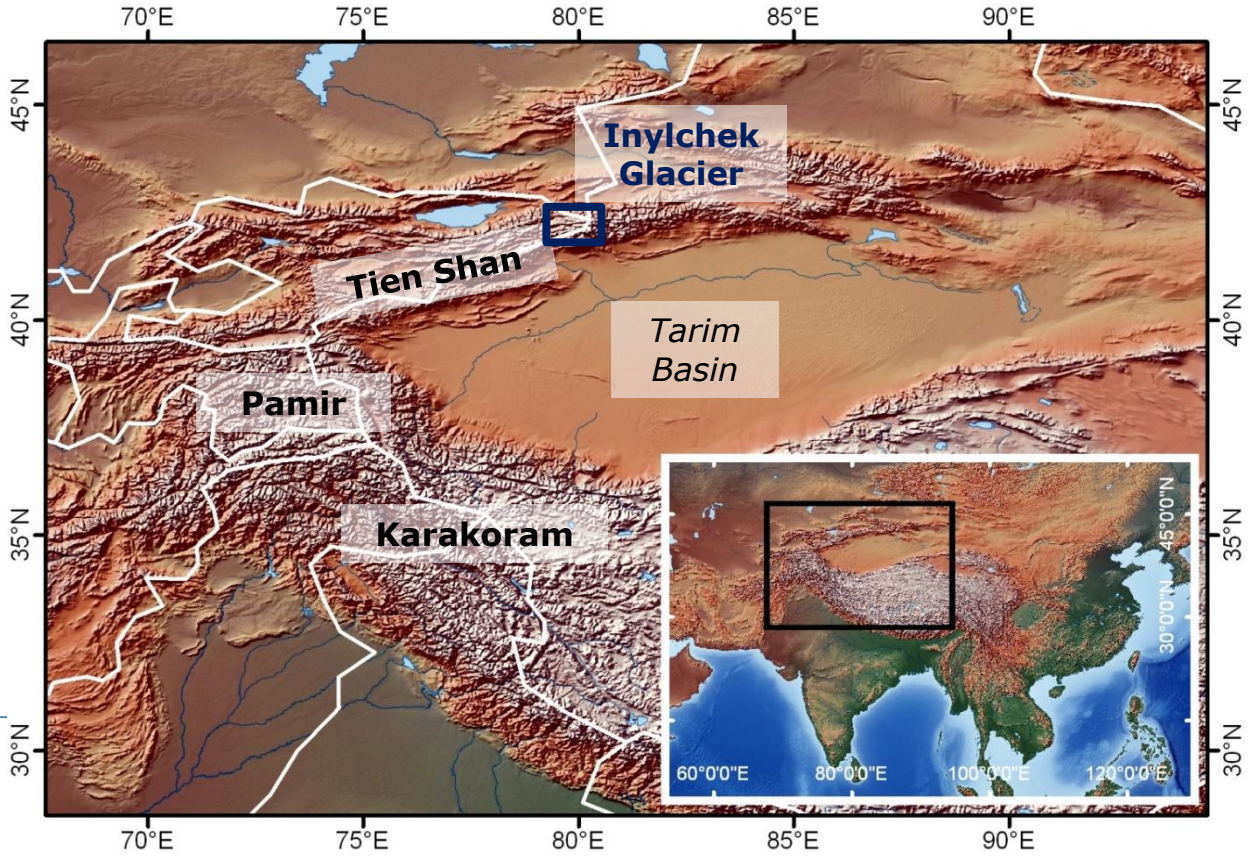
GFZ Helmholtz Centre Potsdam | Universität Potsdam | Leibniz Universität Hannover | Helmholtz Alliance: Remote Sensing and Earth System Dynamics | Helmholtz Association

Motivation

- TanDEM-X satellite mission: generate 12x12 m WorldDEM™ digital elevation model
- Launched: TerraSAR-X: June 2007
  TanDEM-X: June 1010

Research Question: How can high spatial resolution TanDEM-X data contribute to glacier elevation change monitoring in a high mountain area?

Graphic c/o Airbus



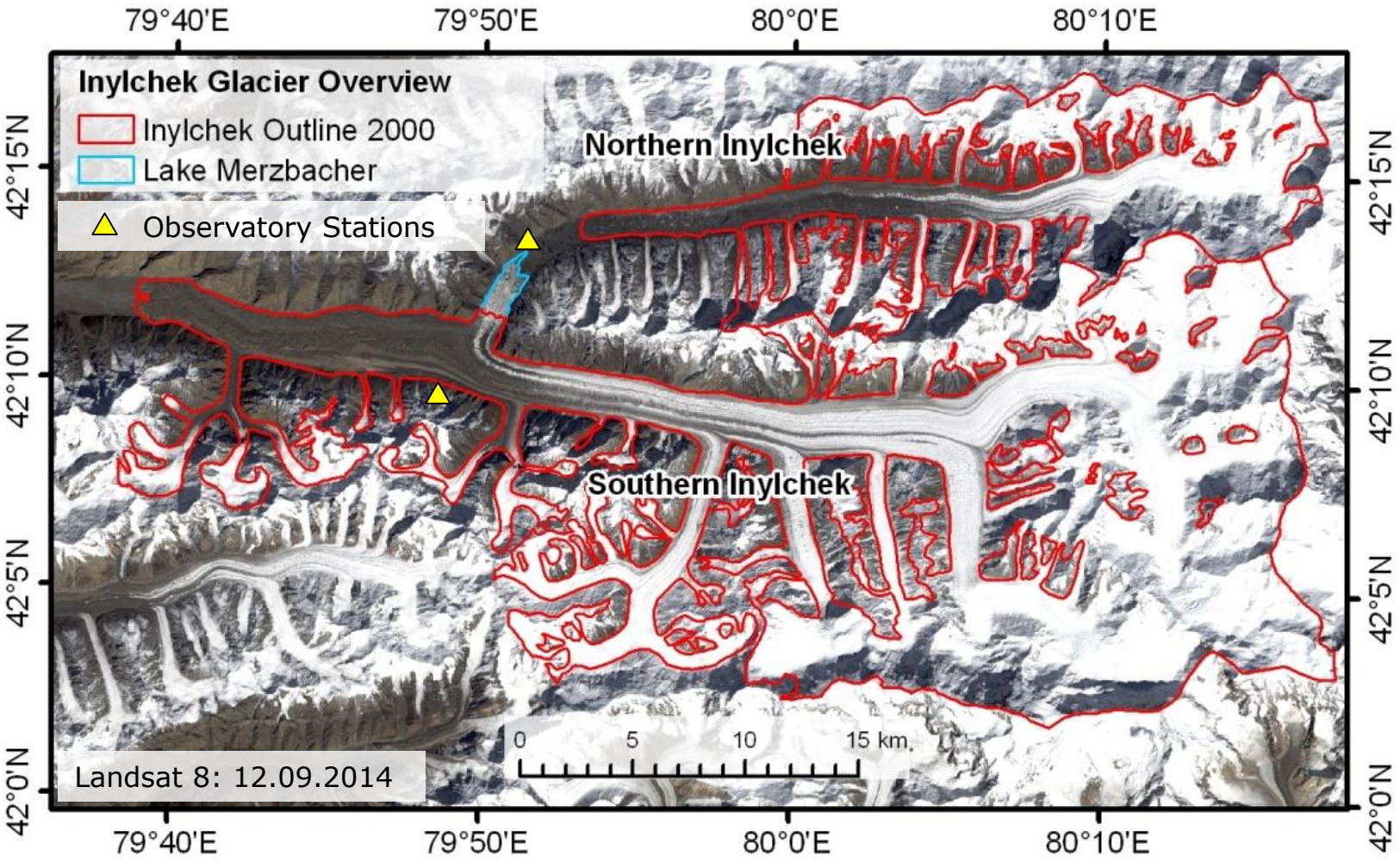
Made with Natural Earth
Free vector and raster map data @ naturalearthdata.com

GFZ Helmholtz Centre Potsdam

HELMHOLTZ ASSOCIATION

Inylchek Glacier - Global Change Observatory Central Asia

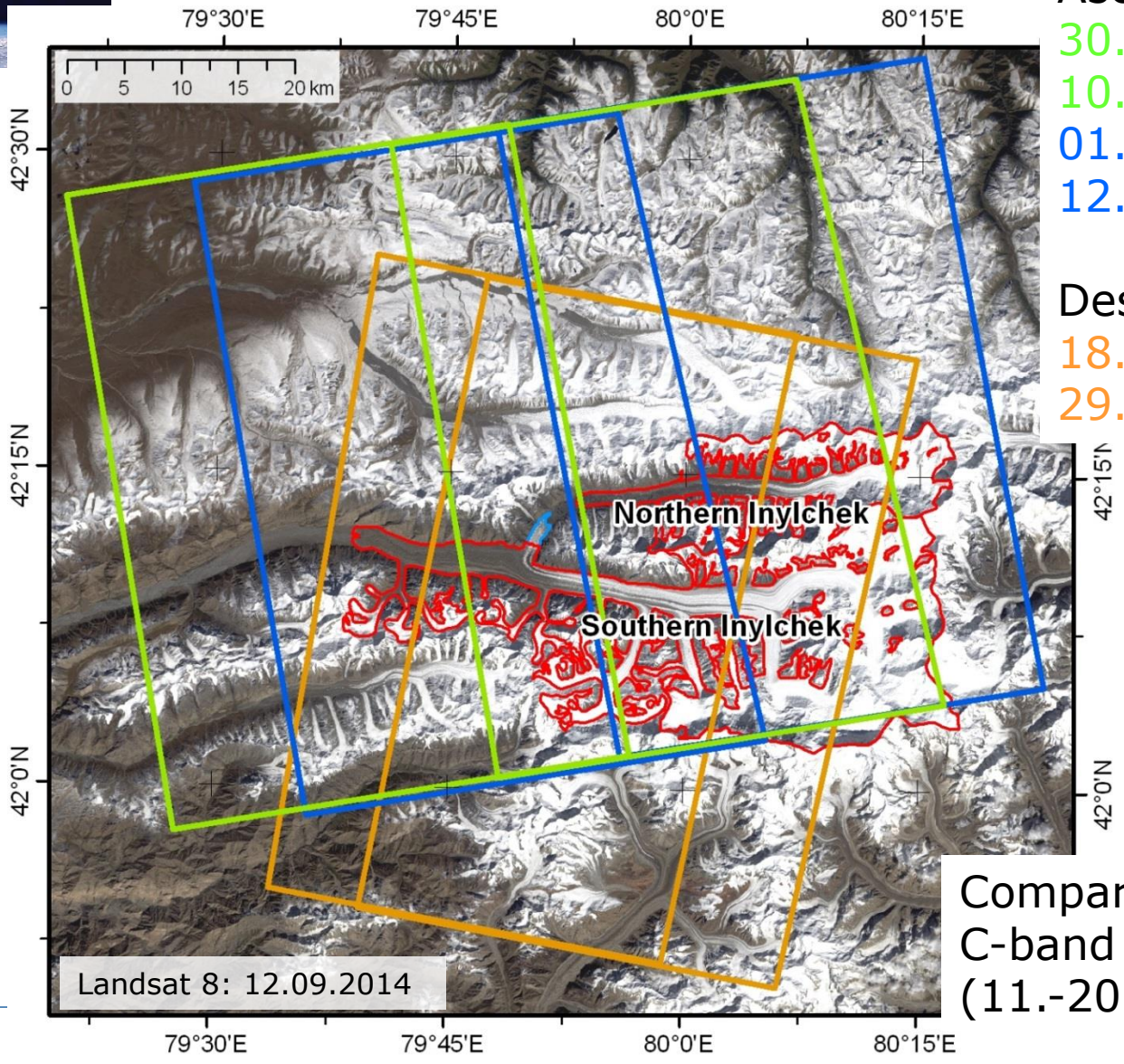
-> first installations in 2009 by GFZ and the
Central Asian Institute of Geosciences (CAIAG)



Inylchek Glacier: ~60 km with complex motion pattern, annual glacier lake outburst flooding of Lake Merzbacher

TanDEM-X (TDX) Data Coverage

Graphic c/o Airbus



Ascending:
30. January 2012
10. February 2012
01. March 2013
12. March 2013

Descending:
18. November 2013
29. November 2013

Comparison to
C-band SRTM DEM
(11.-20. February 2000)

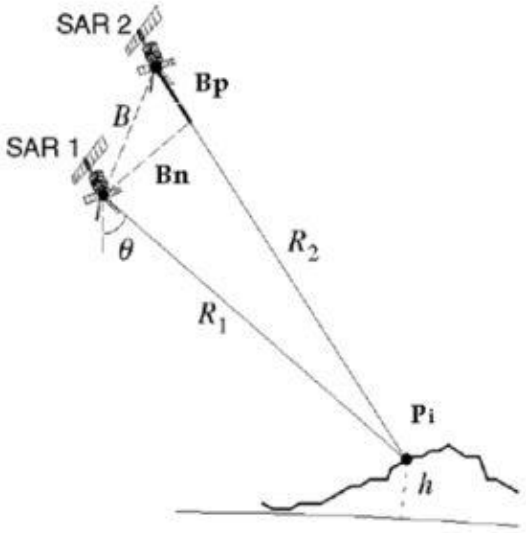
3 mosaicked DEMs: TDX201202, TDX201303, TDX201311

GFZ Helmholtz Centre Potsdam

HELMHOLTZ ASSOCIATION

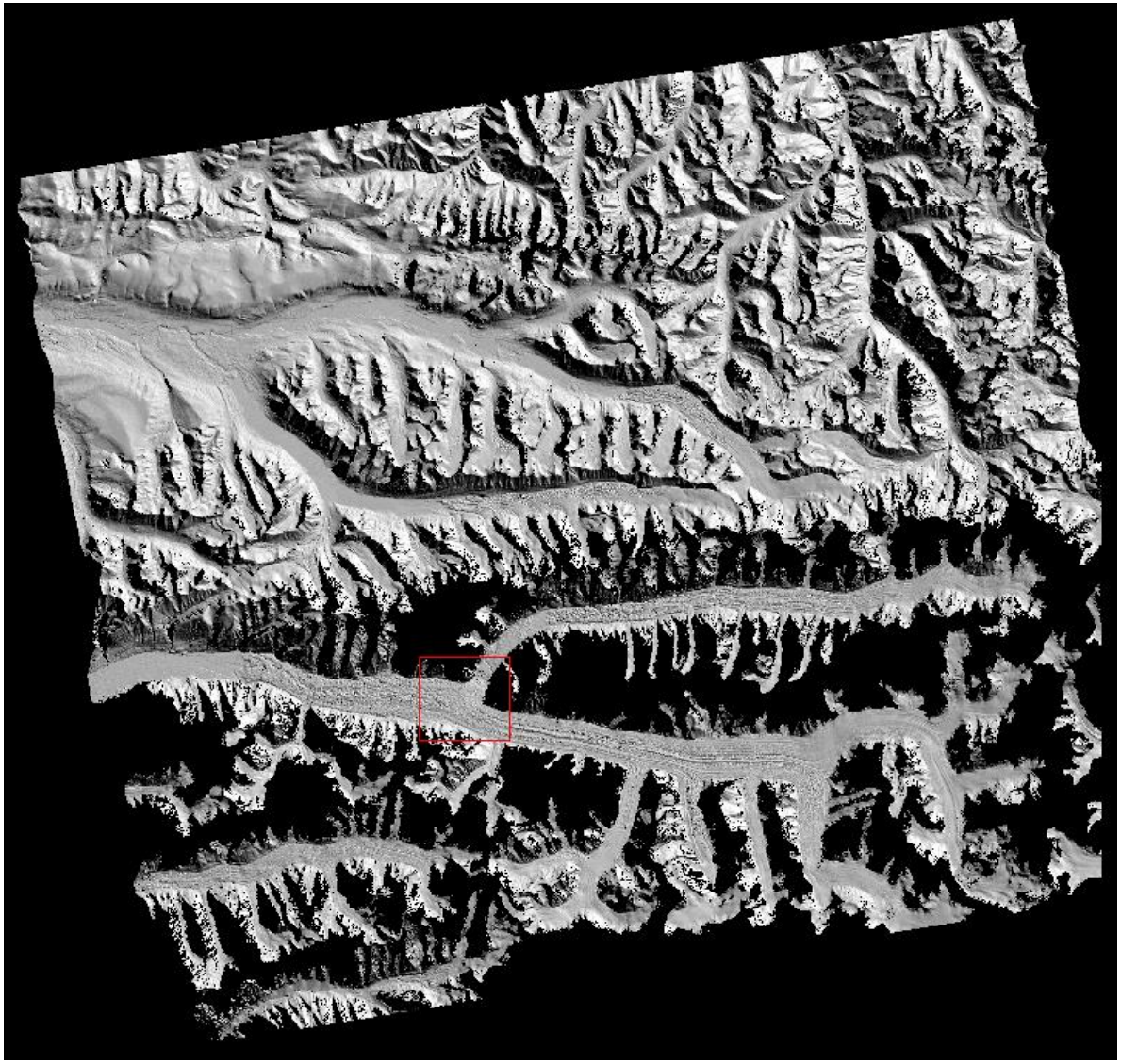
DEM Generation via SAR Interferometry (InSAR)

InSAR



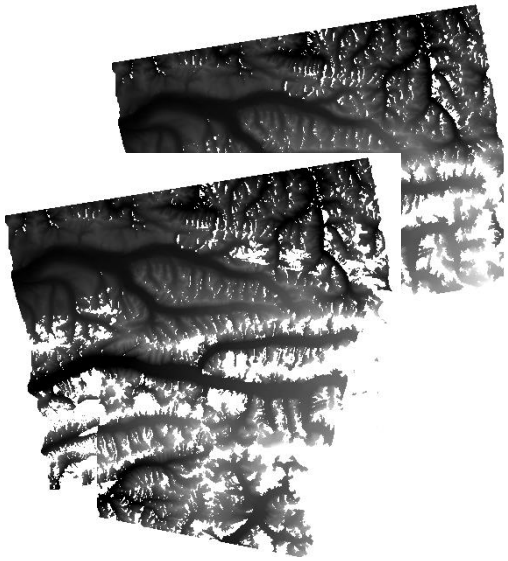
Guido Luzi (2010)
DOI: 10.5772/9090

Exemplary TDX-DEM hillshade from March 2013 (resolution: 10 m)

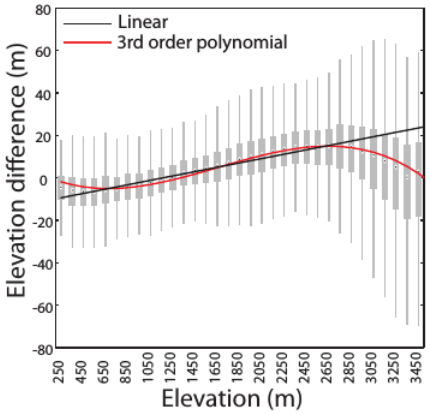


Postprocessing of DEMs

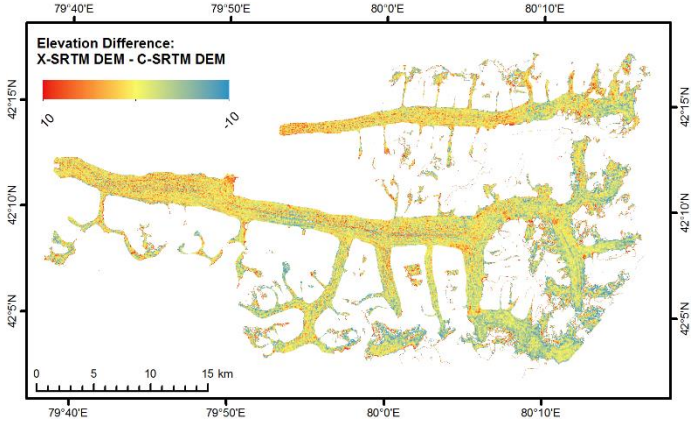
1. coregistration of DEMs (adapted after Nuth and Kääb, 2011)



2. correction of potential elevation bias correction (Nuth and Kääb, 2011)

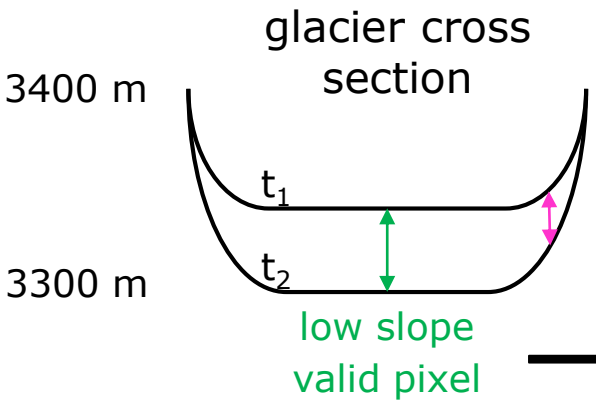


3. radar penetration depth correction between SRTM DEM and TDX DEMs



4. data void handling

Data Void Handling

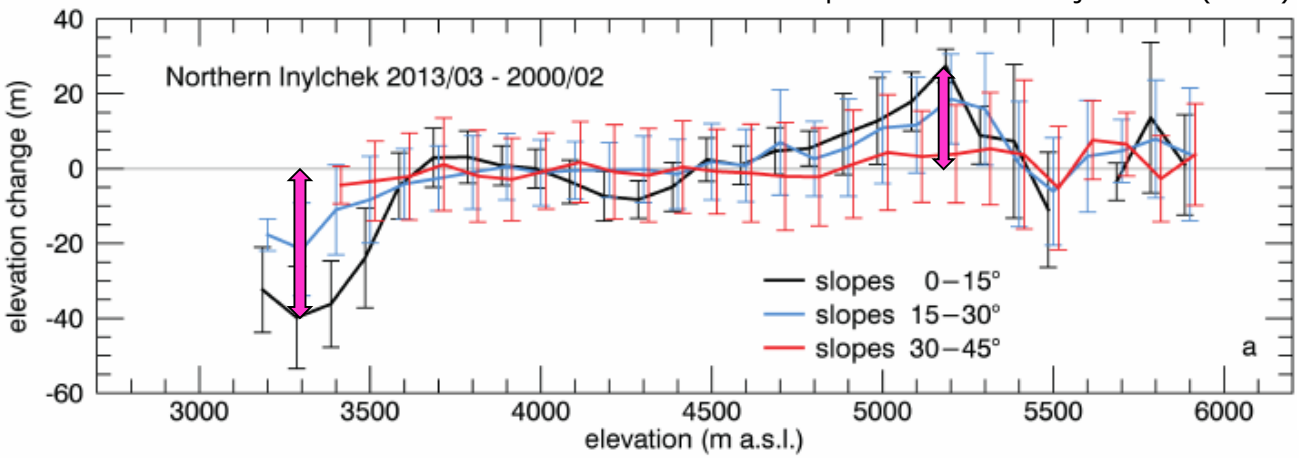


common treatment: apply mean elevation change of same elevation bin to data void area (Gardelle et al. 2012, 2013; Rott et al. 2014)

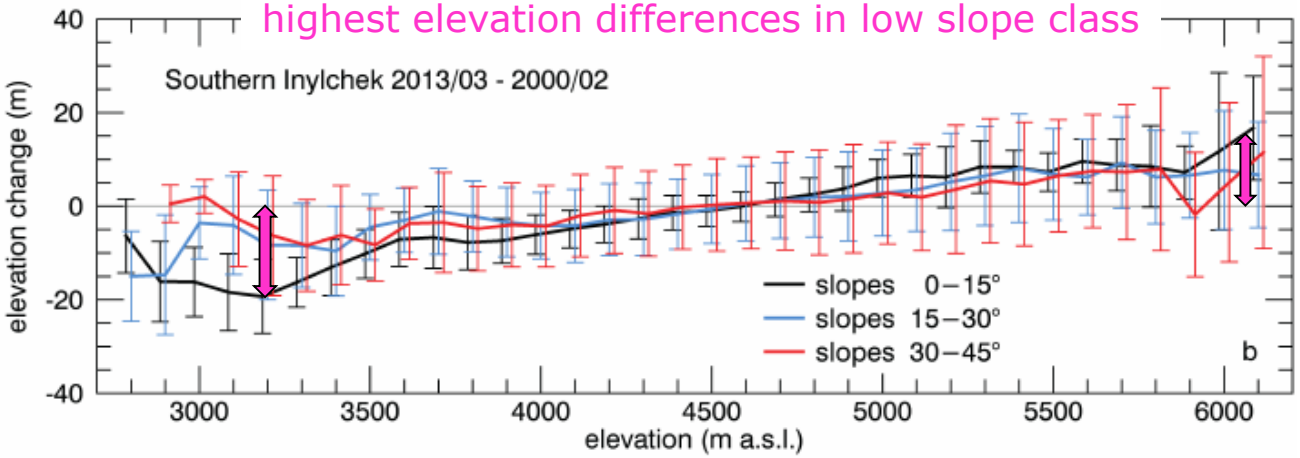
mean elevation difference

mean elevation per elevation bin for different slope classes:

adapted from Neelmeijer et al. (2017)

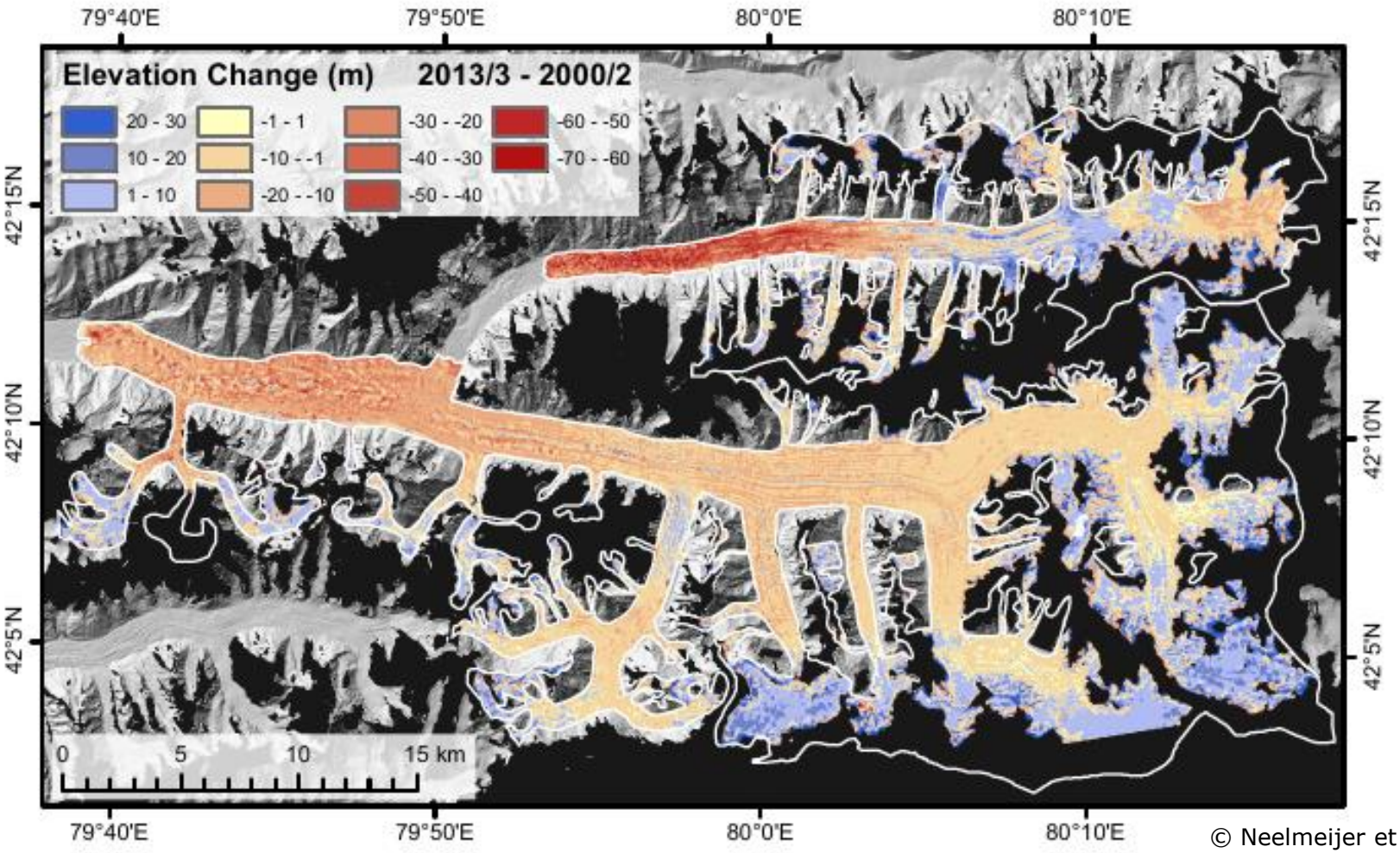


highest elevation differences in low slope class



our solution:
use mean elevation changes depending on elevation bin and slope class to fill data void areas

Inylchek Glacier Elevation Change: February 2000 (SRTM) – March 2013 (TDX)

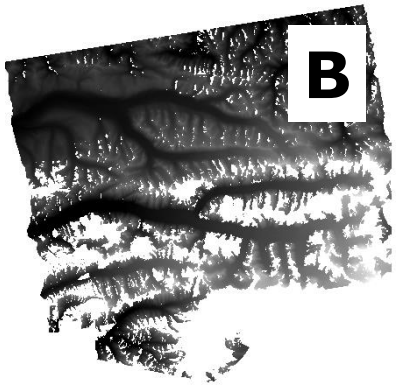


	Northern Inylchek	Southern Inylchek
absolute:	-3.68 ± 5.23 m	-1.98 ± 5.23 m
annual mean:	-0.28 ± 0.40 m a^{-1}	-0.15 ± 0.40 m a^{-1}

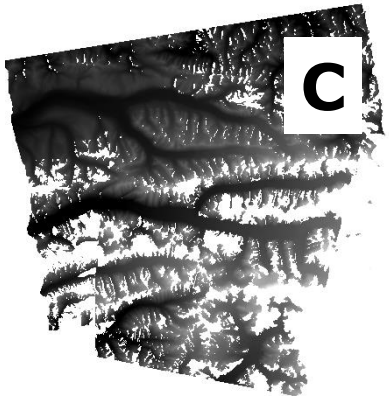
Inylchek Glacier Interannual/Intraannual Elevation Change

TDX DEMs:

TDX201202



TDX201303



TDX201311

Northern Inylchek

A-B: -0.34 ± 1.13 m
B-C: -0.57 ± 1.13 m

Southern Inylchek

A-B: -0.42 ± 1.13 m
A-B: -0.27 ± 1.13 m

vs. -3.68 ± 5.23 m from TDX-SRTM comparison

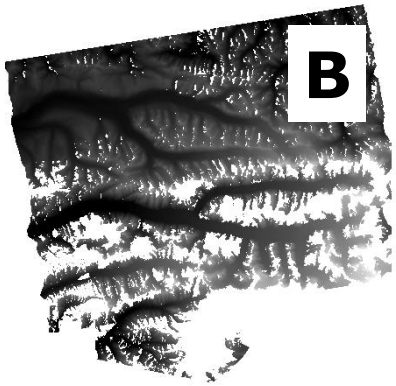
2000-2013
annual mean: -0.28 ± 0.40 m a^{-1}

-0.15 ± 0.40 m a^{-1}

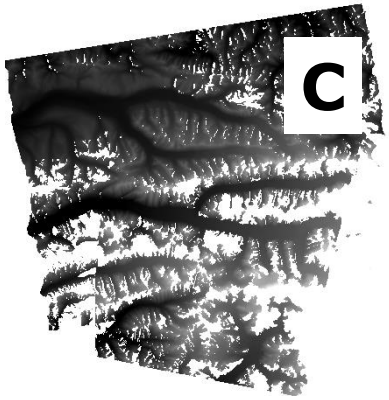
Inylchek Glacier Interannual/Intraannual Elevation Change

TDX DEMs:

TDX201202



TDX201303



TDX201311

Northern Inylchek

A-B: -0.34 ± 1.13 m
B-C: -0.57 ± 1.13 m

(A-B)+(B-C): -0.91 ± 1.13 m
A-C: -0.84 ± 1.28 m

difference: 0.07 m

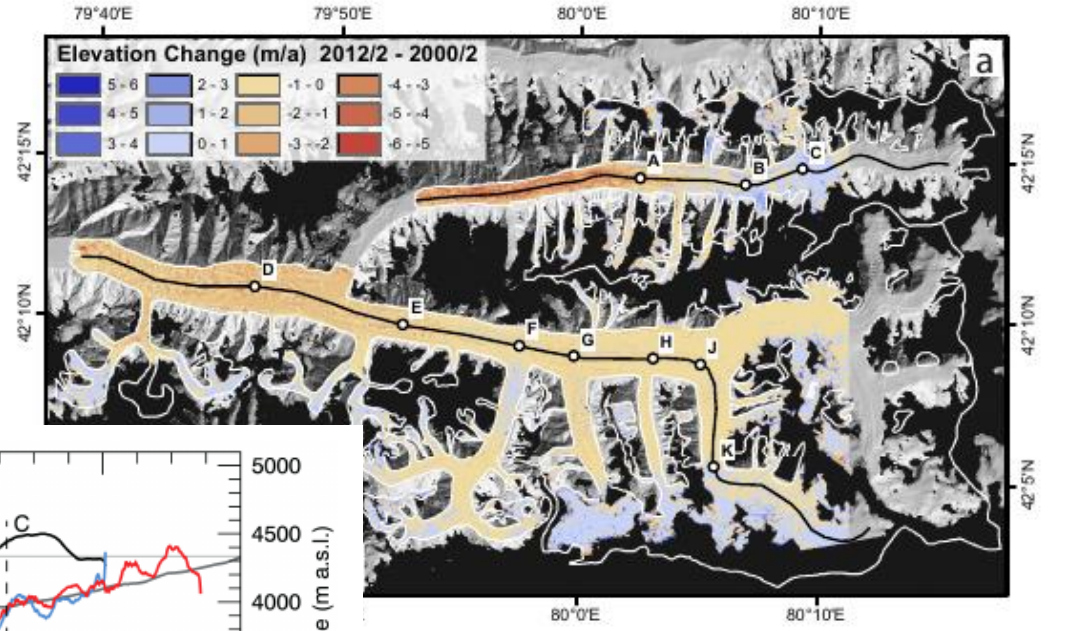
Southern Inylchek

A-B: -0.42 ± 1.13 m
B-C: -0.27 ± 1.13 m

(A-B)+(B-C): -0.69 ± 1.13 m
A-C: -0.72 ± 1.28 m

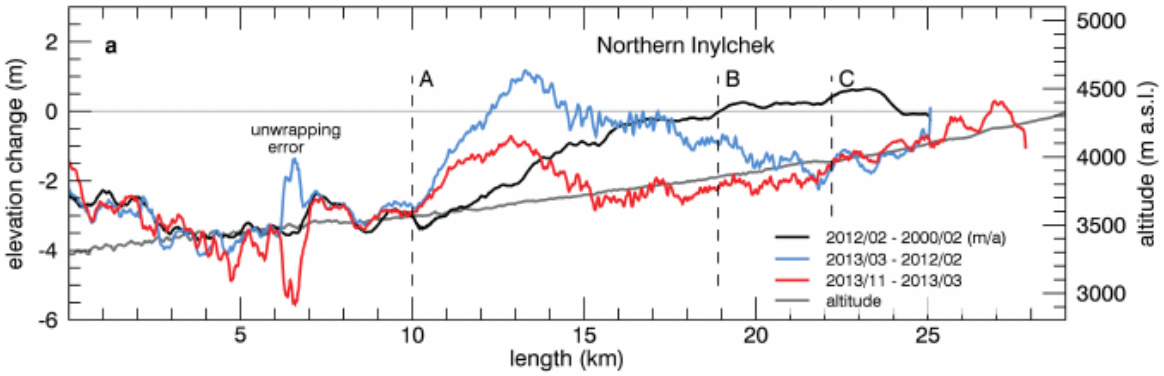
difference: 0.03 m

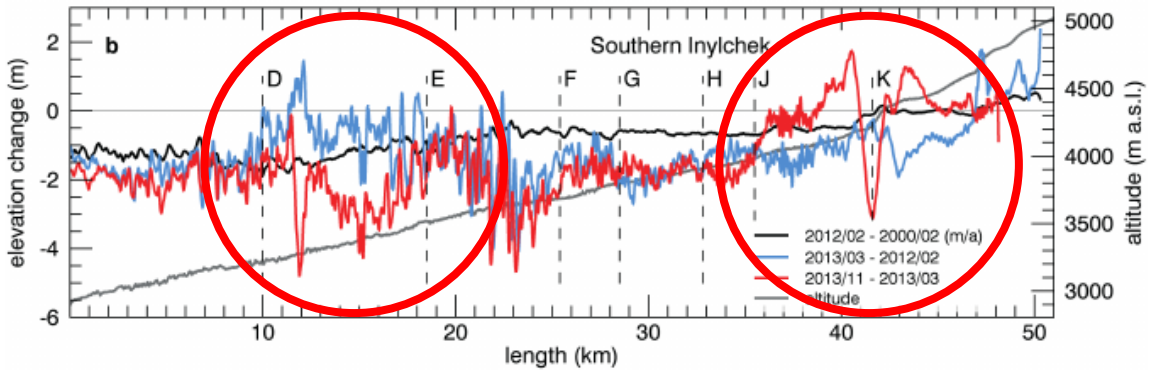
Inylchek Glacier Annual Mean Elevation Change: February 2000 – February 2012



adapted from Neelmeijer et al. (2017)

glacier changes along the flowline:



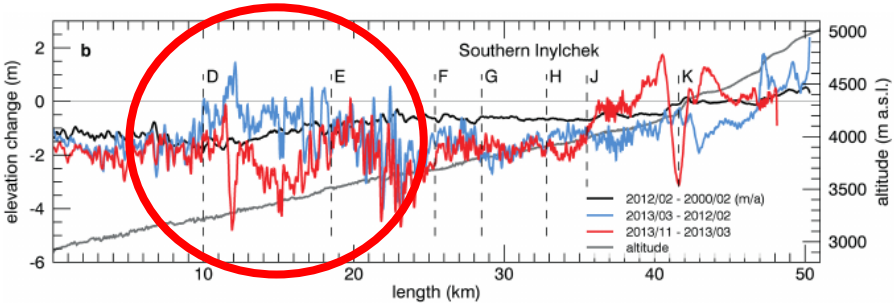


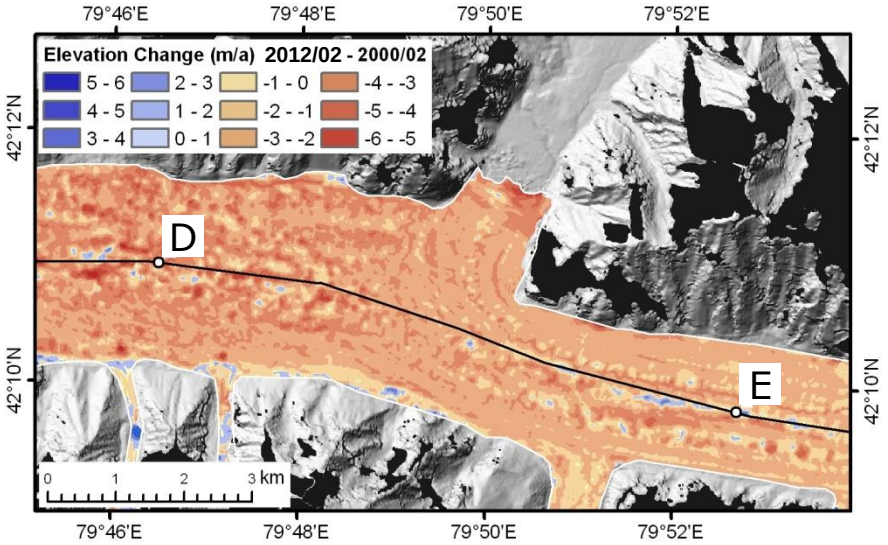
2012/02-2000/02 (m/a)
2013/03-2012/02 (m)
2013/11-2013/03 (m)

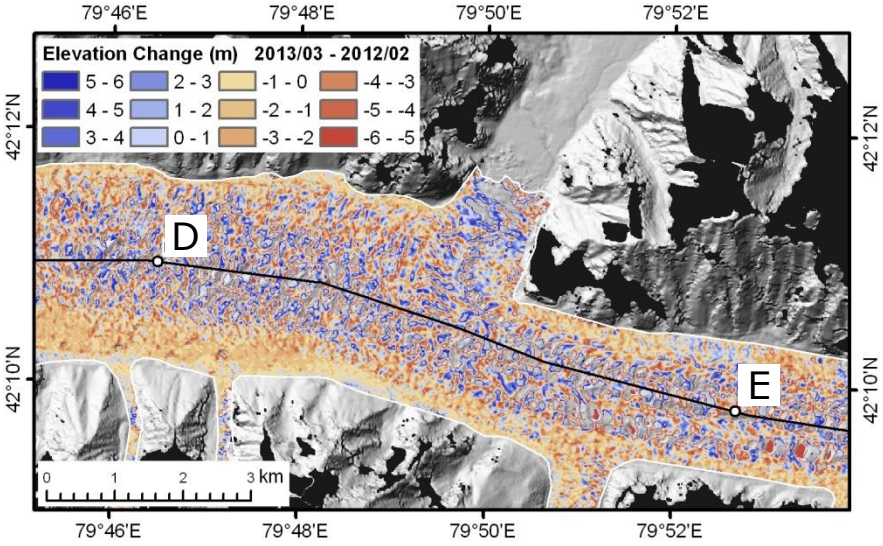
HELMHOLTZ ASSOCIATION

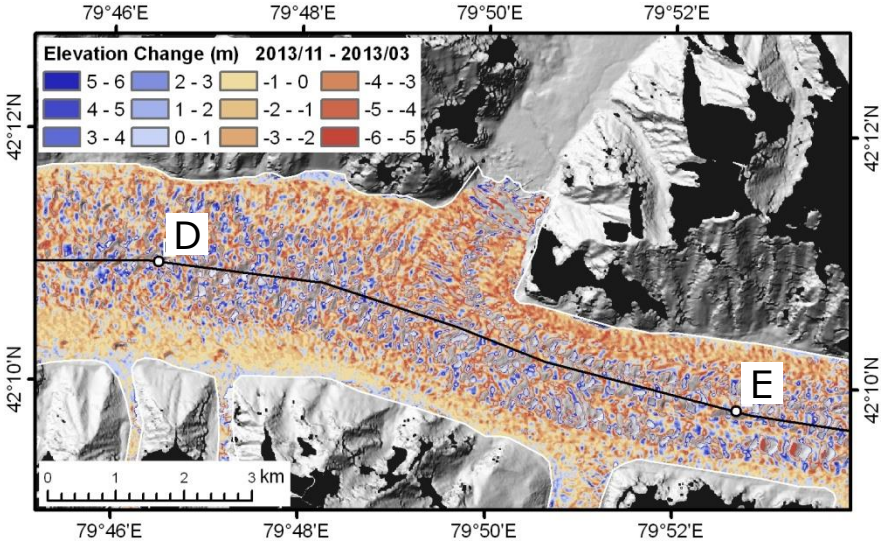
Southern Inylchek Elevation Changes - Lake Merzbacher Influence

2012/02-2000/02 (m/a)
2013/03-2012/02 (m)
2013/11-2013/03 (m)

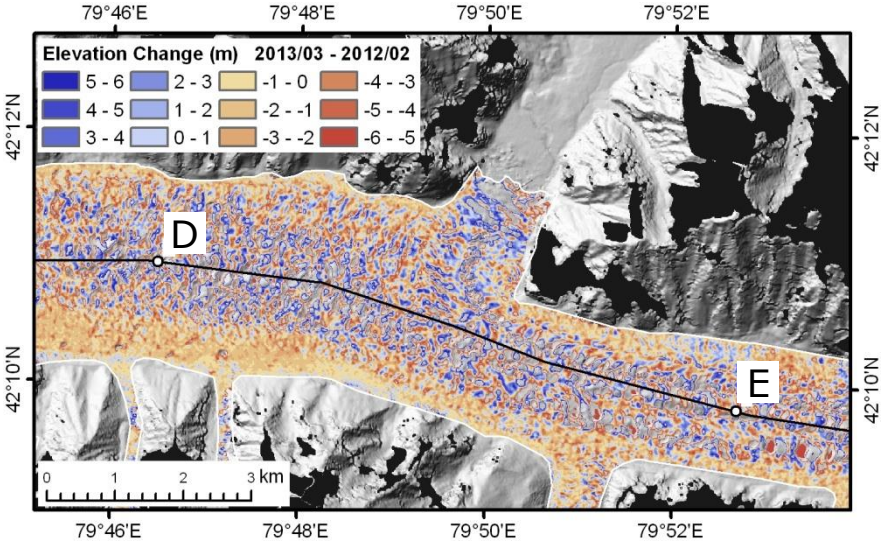


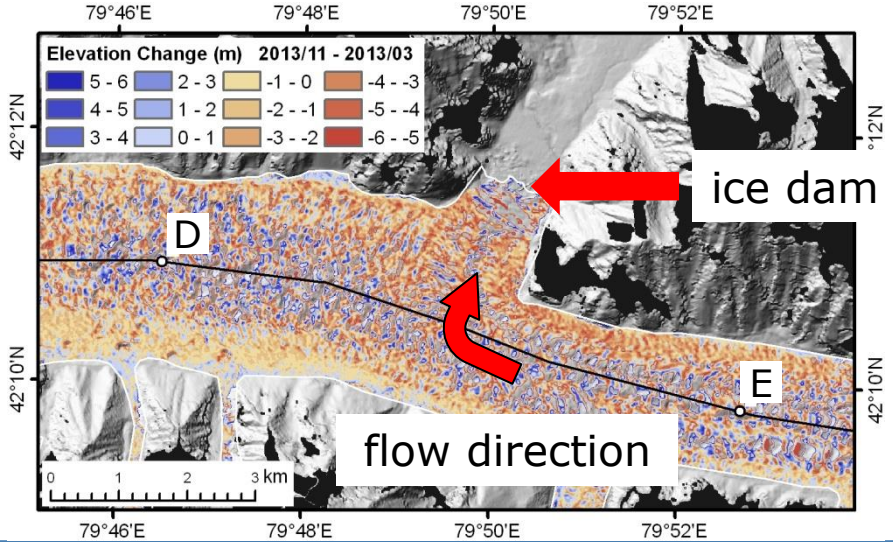


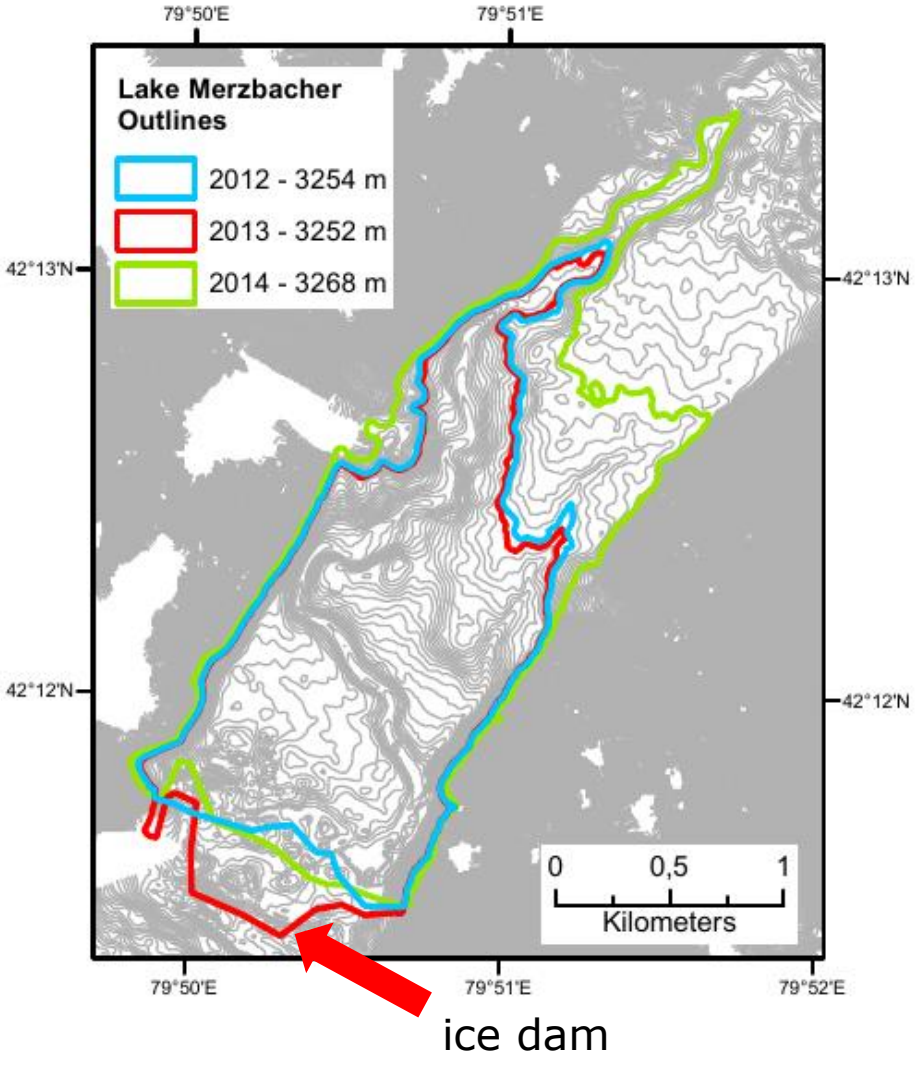




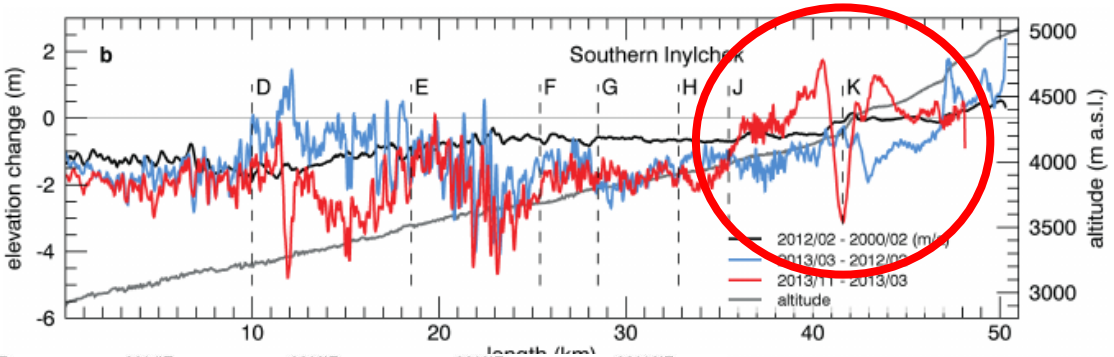
Southern Inylchek Elevation Changes - Lake Merzbacher Influence



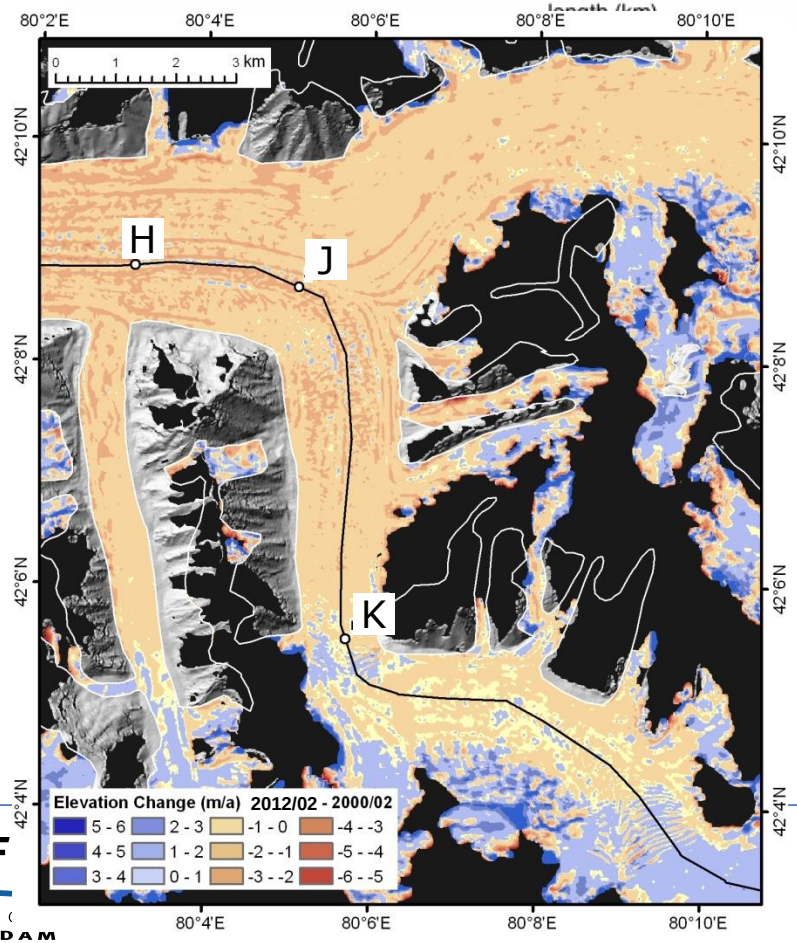


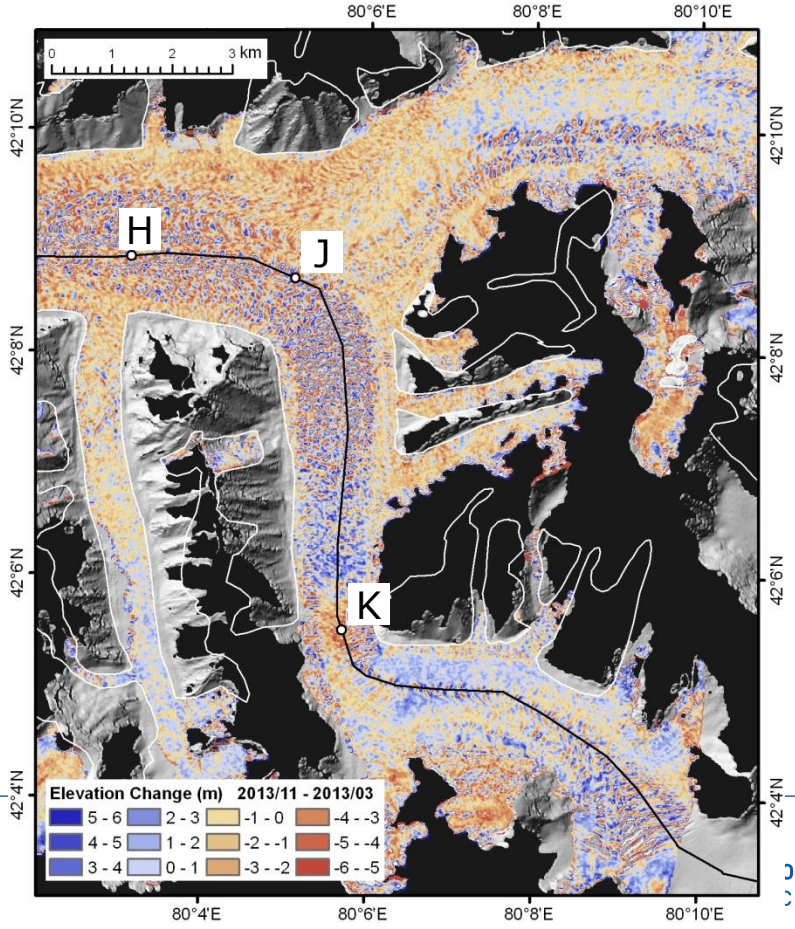


Southern Inylchek Elevation Changes - Icefall



2012/02-2000/02 (m/a)
2013/03-2012/02 (m)
2013/11-2013/03 (m)





Summary

Research Question: How can high spatial resolution TanDEM-X data contribute to glacier elevation change monitoring in a high mountain area?

PRO:

- a comparison of DEMs generated from bistatic TanDEM-X data allows inter- and intraannual glacier elevation change monitoring
- low absolute uncertainty values
- good internal consistency

CON:

- suitable TanDEM-X pairs are only sparsly available
- radar imagery distortions in high mountain area can lead to data voids in glaciated area
- radar penetration depth assumption

J. Neelmeijer, M. Motagh, B. Bookhagen: High-resolution digital elevation models from single-pass TanDEM-X interferometry over mountainous regions: A case study of Inylchek Glacier, Central Asia, ISPRS Journal of Photogrammetry and Remote Sensing, Volume 130, August 2017, Pages 108-121, ISSN 0924-2716, https://doi.org/10.1016/j.isprsjprs.2017.05.011.